

CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-105

December 19, 1980

1. Name of fault:

SE segment of Hayward fault, Crosley fault, Berryessa fault, Quimby fault, Clayton fault, SE segment of Mission fault, and inferred break of 1868.

2. Location of faults:

Milpitas and Calaveras Reservoir 7.5 minute quadrangle, Alameda and Santa Clara Counties (figure 1).

3. Reason for evaluation:

Part of 10-year fault evaluation plan (Hart, 1980).

4. Reference:

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5. Review of available data, air photo interpretation, field checking:

The southern extension of the Hayward fault zone (figure 1) will be evaluated in 2 Fault Evaluation Reports (FER) divided as follows: Milpitas and Calaveras Reservoir 7.5 minute quadrangles, FER - 105 (this report) and San Jose East and Lick Observatory quadrangles, FER - 106. Evaluation of the Calaveras fault zone will not be included in these FER's, but will be evaluated in separate reports as time and priorities permit.

The Hayward fault zone in the Milpitas and Calaveras Reservoir quadrangles is a complex fault zone consisting of generally right-lateral strike-slip deformation in the northernmost area of study, and complex strike-slip and reverse-oblique faulting southeast of the Milpitas quadrangle (Dibblee, 1972, 1973). Topography along the fault zone ranges from gently rolling foothills in the northern portion of the study area to rugged relief along the fault zone in the southeastern part of the study area. Land surface along much of the Hayward fault zone has been extensively modified by man, such as the location of Highway 680 over the main trace of the Hayward fault in the northern Milpitas quadrangle, and extensive suburban development along the foothills on much of the Calaveras Reservoir quadrangle. Widespread Holocene and historic landsliding characterizes many of the west-facing slopes where the Hayward fault zone has been mapped (figures 3a, 3b).

Lithology encountered along the fault zone includes rocks of the Franciscan Formation, Cretaceous sandstone, shale and conglomerate, Miocene Briones, Orinda, and Monterey Formations, and Plio-Pleistocene Santa Clara Formation. Many of these formations have been internally sheared and deformed during a number and variety of geologic events, including, but not limited to, deformation caused by movements along the Hayward fault zone. A number of site-specific fault investigations have been performed along traces of the Hayward fault zone, but results generally have been inconclusive

or contradictory, due in part to the complexity of the fault zone and also the sheared, complex nature of the geologic materials along the fault zone.

The Hayward fault zone depicted on the 1974 Special Studies Zone Maps (SSZ) of the Milpitas and Calaveras Reservoir quadrangles is comprised of many traces, most of which have been named by Dibblee (figure 2a, b). The 1974 SSZ Map of the Calaveras Reservoir quadrangle incorrectly references mapping by Dibblee as issued in 1972. Correct date is 1973. For this FER, each fault trace will be evaluated individually as shown in figures 2a, 2b.

Hayward Fault

The Hayward fault depicted on the 1974 SSZ Maps of the Milpitas and Calaveras Reservoir quadrangles was based on mapping by Dibblee (1972, 1973), Radbruch (1968) and Burkland and Associates (1974) (figures 2a, 2b). The westerly trace of the Hayward fault of Radbruch (1968) on the Milpitas quadrangle (figure 2a) is based on the Crittenden (1951).

The Hayward fault is relatively well-expressed in the very northern portion of the Milpitas quadrangle and is characterized by multiple traces delineated by scarps in alluvium, offset drainages, tonal lineaments in alluvium, benches, and sag ponds indicating right-lateral strike-slip displacement along vertical to near vertical fault traces (figure 3a). South of Mission Boulevard specific evidence for Holocene faulting becomes less systematic and discontinuous. Fault creep has been documented north of the Milpitas quadrangle (Hart, 1979), but no evidence of fault creep has been observed south of Fremont (Nason, 1971). No evidence of systematic offset of curbs, sidewalks, or other man-made features was observed by this writer along Mission Boulevard where it crosses traces of the Hayward fault (figure 3a).

The Hayward fault on the Calaveras Reservoir quadrangle is based almost entirely on Dibblee (1973) (figure 2b). Traces of the Hayward fault in this portion of the study area are characteristic of moderate to steeply dipping

faults, rather than vertical or near vertical faulting typically found to the northwest. The Hayward fault offsets rocks of the Plio-Pleistocene Santa Clara Formation, Tertiary Briones Monterey and Orinda Formation against Cretaceous sedimentary rocks. Faulting along most of this area is obscured by recent landsliding (Dibblee, 1973; Nilsen, 1972, Nilsen and Brabb, 1972; Herd, 1977, and in press). Trenches excavated in an investigation by Woodward-Clyde and Associates (1970) crossed Crittenden's trace (1951) of the Hayward fault (figure 2a). Crittenden's location of this fault trace, shown by Radbruch in her 1968 and 1974 maps, is only approximately located as a concealed trace on a small-scale diagram with no topographic control (Crittenden, 1951, p. 50). The site investigation found no evidence for the existence of Crittenden's fault trace or the existence of Dibblee's concealed trace of the Hayward fault 250 feet east of Crittenden's trace (figure 2a). Woodward-Clyde (1970) stated that the surface trace of the Hayward fault was probably located along the base of the hills just east of the site investigation, although they did not extend trenches far enough east to establish the precise location of this trace.

Herd (1977) shows late Quaternary traces of the Hayward fault on the Milpitas quadrangle (figure 2a). Herd did not find evidence for late Quaternary traces of the Hayward fault 6,000 feet south of the Alameda-Santa Clara County boundary and could not find evidence for recently active traces of the Hayward fault on the Calaveras Reservoir quadrangle (Herd, in press) (figure 2a,b).

Several fault investigations have been conducted along traces of the Hayward fault since the 1974 SSZ maps of the Milpitas and Calaveras Reservoir quadrangles were first issued (figures 2a, 2b). Three site investigations

(Terrasearch, 1971, 1977b, 1979) along the southwest end of Radbruch's 1968 fault trace (based on Crittenden, 1951) did not find evidence for faulting, although none of the investigations crossed the inferred fault trace.

Well-defined fault traces occur south of Scott Creek Road and can be followed for about 4,500 feet, based on Dibblee (1972), Herd (1977), and air photo interpretation by this writer (figures 2a, 3a). Allied Geophysics (1976) trenched across one of these traces and found faulting that seems to offset the youngest soil deposits (figure 2a). Earth Systems Consultants (1978a) identifies traces of the Hayward fault (figure 2a) 2,000 feet south-east of the Allied Geophysics location. However, a landslide headscarp-graben slip surface is equally compatible with the shears observed in the trenches. Geomorphic features at this site strongly indicate landsliding, further supporting a landslide interpretation (figure 3a). Nilsen (1972) and Herd (1977) also interpret this area as a landslide.

The Hayward fault is exposed in a road cut along Calaveras Road where Cretaceous Berryessa Formation is faulted against Plio-Pleistocene Santa Clara Formation. Northwest of this road cut, vague geomorphic features indicating recent faulting (bench, back^Afacing scarp disrupted, but not offset drainage) can be followed, but southeast of Calaveras Road geomorphic evidence for recent faulting is discontinuous and is generally obliterated by Holocene and historic landsliding (figure 3b).

Only one A-P site investigation on file with California Division of Mines and Geology (Geoconsultants, 1976) involved trenching across the Hayward fault on the Calaveras Reservoir quadrangle (figure 2b). The Hayward fault at this

location is mapped by Dibblee (1973) as concealed by landsliding (figure 2b). Geoconsultants (1976) found a fault that juxtaposed Miocene Briones sandstone against Cretaceous Berryessa Formation. The fault, which dips moderately to the east, was confined to bedrock and did not offset overlying soil deposits. The consulting report stated..."there is no evidence to indicate that the fault is currently active". However, a setback was recommended because of the association of this feature with the Hayward fault zone.

Air photo interpretation by this writer of fault traces along the Hayward fault in the Calaveras Reservoir quadrangle is summarized on figure 3b. The Hayward fault in this area is not well-defined. Discontinuous features permissive of faulting are located between Piedmont Creek and Berryessa Creek (figure 3b). However, the proximity to mapped Holocene active landslides and the geometric relationship of the geomorphic features allow an alternative interpretation of a landslide origin. Dibblee's (1973) trace of the Hayward fault cannot be located southeast of Berryessa Creek. Massive landsliding and erosion are the ^{predominant} ~~predominate~~ geologic processes. -

Crosley Fault

The Crosley fault depicted on the 1974 SSZ Map of the Milpitas and Calaveras Reservoir quadrangles was mapped by Dibblee (1972, 1973) (figures 2a, 2b). Dibblee mapped this fault based on the offset of Cretaceous rocks over Plio-Pleistocene Santa Clara Formation. Dibblee's location of the Crosley fault generally follows the base of the west-facing slope and is depicted as concealed in the Milpitas quadrangle and concealed through most of the Calaveras Reservoir quadrangle. Exposures of the Crosley fault can be seen in Crosley Creek, where serpentine of the Franciscan Formation is thrust over Plio-Pleistocene Santa Clara Formation (figure 3b). The fault at this location dips steeply to the northeast.

The Crosley fault depicted by Dibblee is generally a reverse to reverse-oblique fault with a northeast dip that ranges from 20° to vertical. The east side is uplifted relative to the west. South of Crosley Creek the fault trace lies within extensive landslide deposits and is depicted as trending along the west-facing slope of the mountain front east of the toe of the slope. The Crosley fault terminates to the south near the San Jose Hospital where the fault presumably joins with the main trace of the Hayward fault, although the precise location of both of these faults is concealed by Holocene landslide deposits.

The youngest deposit truncated by the Crosley fault ^{of} (1972, 1973) Dibblee is the Plio-Pleistocene Santa Clara Formation, although at one and location about halfway between Cropley Creek (now called Sweigart Creek) and Crosley Creek Dibblee shows serpentine ^{against} ~~some~~ alluvium (figure 3b). Helley and Brabb (1971) depict this alluvium as Qof (older fan deposits of late Pleistocene age). Nilsen (1972) shows the area that was mapped by Dibblee as serpentine to be a massive landslide (figure 3b).

Earth Systems Consultants (1978c) conducted a fault investigation in the vicinity of Cropley Creek (Sweigart Creek) and located traces of the Crosley fault (figure 2b). The fault, delineated at the surface by a line of springs and seeps, extended to the surface and cut all soil deposits. The fault has a vertical dip just south of Cropley Creek, but flattens to a dip of 50° E about 800 feet south of Cropley Creek (figure 3b). Air photo interpretation by this writer confirms the location of a linear tonal contrast in the area where Earth Systems Consultants (1978c) located the Crosley fault (figure 3b).

Evidence for the location of the Crosley fault in the Milpitas quadrangle is contradictory. Four A-P site investigations on file with CDMG

(Pendergast, 1976; Terrasearch, 1977a, Burkland and Associates, 1976; Bay soils, 1977a) failed to locate evidence for the Crosley fault (figure 2a). Burkland and Associates (1976) excavated 9 trenches across the site from Evans Road east (figure 2a). No faulting was found along the mapped trace of the Crosley fault, though 3 caliche filled cracks were located near the Crosley fault trace. The cracks did not extend into the overlying soil and lithology across the cracks was not disrupted. Burkland and Associates concluded that the cracks were not fault related. Additional site investigations by Burkland and Associates (1977a and 1977b) are located north of Burkland and Associates (1976) and south of Calera Creek (figure 2a). Trenches excavated by Burkland and Associates (1977b) exposed low angle, northeast dipping faults that offset Holocene soil deposits. Burkland and Associates (1977a) excavated trenches that exposed faulting that variously dipped to the northeast, southwest, and vertically (figure 2a). Nilsen (1972) depicts the toe of a landslide where Burkland and Associates (1977a) shows faulting (figure 3a).

Herd (1977) has mapped most of this area as landslides and does not show the Crosley fault in this area, or along the base of the west-facing slope throughout the Calaveras Reservoir quadrangle, except for a 1000-foot trace south of Piedmont Creek (figure 2b) (Herd, in press). Burkland and Associates (1974) did not find evidence for the Crosley fault in the vicinity of Calaveras Road (figure 3b).

Earth Systems Consultants (1978b) located traces of the Crosley fault in three trench excavations just north of Berryessa Creek (figure 3b). The fault plane was generally oriented N50° - 60°W and dipped from 20° to 30° NE. The

fault offsets "youngest alluvial or soil layers".

glot Judd Hull and Associates (1977) located the Crosley fault along Dibblee's trace near Cro^PAley Creek (figure 2b, 3b). A trench near the eastern portion of the property exposed a fault dipping very steeply to the east. The shear plane extended into the soil and there was a distinct thickening of soil over the fault. A second trench 35 feet east of the previously mentioned trench also encountered what was described as the Crosley fault. However, two shears were exposed, both dipping moderately to the southwest. The headscarp boundary of a recently active landslide coincides with the location of these southwest-dipping shears, although lithologic conditions do not suggest landsliding.

Kaldveer and Associates (1978) investigated a site southeast of Crosley Creek (figure 2b). The Crosley fault was mapped in Cro^PAley Creek and exposed in a trench. The fault in Cro^PAley Creek dips steeply to the northeast, but the shear exposed in the trench dips to the southwest at a moderate angle. The consulting report stated that "...evidence for active fault movement on the parcel is inconclusive, but the fault has offset Pleistocene-age Santa Clara Formation, making it at least potentially active."

Air photo interpretation of the Crosley fault by this writer indicates that landsliding is the dominant geologic process in this area (figure 3a, 3b). Isolated features (such as sidehill benches, tonal lineaments across Holocene surface) related to faulting can be found along the trace of the Crosley fault but systematic evidence for Holocene active faulting cannot be found.

Berryessa Fault

The Berryessa fault of Dibblee (1973) is based on the juxtaposition of Santa Clara Formation against serpentine of the Franciscan Formation. The Berryessa fault does not cut rocks younger than Plio-Pleistocene Santa Clara Formation (Dibblee, 1973). Dibblee indicates that displacement along the Berryessa fault is predominantly

right-lateral strike-slip, although the mapped trace of the fault is characteristic of a moderate to steep east-dipping fault (figure 2b).

Burkland and Associates (1978) identified a shear zone about 650 feet east of Dibblee's trace of the Berryessa fault (figure 2b). The shear zone, which coincided with a formational contact, did not extend into the youngest, or uppermost soil layer. Evidence for Dibblee's trace of the Berryessa fault was not found in this investigation.

No evidence of the Berryessa fault was found by Kaldveer and Associates (1978) (figure 2b). Trenching, magnetometer surveys, and mapping of Crosley Creek produced no evidence for the location of the Berryessa fault.

The Berryessa fault was located during a fault investigation by William Cotton and Associates (1979) (figure 2b). Although a setback was recommended, based on an apparent offset of "colluvial material", the fault did not extend into the 3-foot thick soil layer. The "colluvium" shown to be offset (mapped on the northeast side of the fault) may actually be Santa Clara Formation. Dibblee (1973) shows an outcrop of Santa Clara Formation along the northeast side of the Berryessa fault very close to this location.

Todd Nelson, former engineering geologist for the City of San Jose, indicated that geotechnical investigations have shown that the Berryessa fault is probably inactive (Earth Systems Consultants, 1978b).

Air photo interpretation by this writer indicates that most of the area along the Berryessa fault trace is characterized by massive slope failures (figure 3b). Southeast of Crosley Creek a vague sidehill bench and right-laterally deflected drainage are located near Dibblee's trace of the Berryessa fault (figures 2b, 3b). However, continuity of this feature to the northwest and southeast cannot be observed. The close association of Holocene active landslides suggest that a landslide origin is equally compatible with the geomorphic evidence.

Quimby Fault

The Quimby fault depicted on the 1974 SSZ Map of the Calaveras Reservoir quadrangle is based on Dibblee (1973) (figure 2b). Only the very northern segment of the Quimby fault is shown on the Calaveras Reservoir quadrangle. Dibblee seems to have based his mapping of the Quimby fault on the Calaveras Reservoir quadrangle on the linearity of Dutard Creek, the general location of the mountain front just south of Upper Penitencia Creek, and the general northward projection of the fault located in the San Jose East quadrangle (figure 2b). Dibblee depicts the Quimby fault as a high-angle reverse fault.

Terratech (1979) located a "fault" about 250 feet west of the mapped trace of the Quimby fault (figure 2b). Evidence for faulting was inconclusive. Although no fault plane or shear zone was exposed in trench ^X excavations, the presence of faulting was based on 1) thickening of "topsoil"; 2) easterly dip of "alluvial material" where a geophysical (not specified what kind of geophysical survey conducted) anomaly was found; 3) deflection of Miguleta Creek; 4) unspecified photo lineaments aligning with the deflection of Miguleta Creek. The deflection of Miguleta Creek is probably caused by an outlier of bedrock lying immediately west of the deflected stream course, based on air photo interpretation by this writer and Nilsen (1972) (figure 3b). The nature of the alluvial materials described in the consulting report (discontinuous lenses of gravel and silt-filled channels) suggest that the "fault" described in the trench could be the west wall of a scour and fill channel. The depth of the trench generally was not adequate in order to establish whether or not the alluvial material is truncated, or, as implied by the overlying soil, defines a small channel. Fractures, which are implied to be fault-related, are confined to a pinkish-white sandy clay. Underlying clayey sand and overlying gravel are not fractured. The interfingering of medium orange-brown clayey sand and the sandy silt along the west boundary of the "fault zone" suggest ^S facies changes in an all ^uuvial fan depositional

environment. Perhaps this feature was an ephemeral tributary channel drainage into Miguelita Creek.

A setback was recommended as the result of a fault investigation by Terratech (1978b) (figure 2b), although evidence for faulting was not exposed during trench excavations. The setback was recommended because of "anomalous results of seismic refraction surveys" and because of the abrupt deflection of Dutard Creek north of the site (figures 2b, 3b). The deflection of Dutard Creek is caused by active, massive landsliding rather than faulting (figure 3b). North of this site, United Soil Engineering (1976) interpreted a similar seismic refraction anomaly to be a channel fill deposit. This channel fill deposit was encountered in subsequent trenching excavation.

Terrasearch (1977c) exposed a shear during a fault investigation just south of Upper Penitencia Creek (figure 2b). Cretaceous Oakland Conglomerate was juxtaposed against "reddish-brown sandy clay". The shear plane dips steeply to the southwest and strikes northwest. This shear, located about 450 feet northeast of Dibblee's trace of the Quimby fault, is within colluvial deposits mapped by Nilsen (1972) and may be an alluvium-bedrock contact. Bay Soils, Inc. (1977b) excavated a trench 400 feet southwest of Terrasearch's shear, across the projected trace of the fault (figure 2b). No evidence of faulting was found. Geomorphic expression of this feature could not be found, based on air photo interpretation by this writer and mapping by Herd (in press).

Clayton Fault

The Clayton fault depicted on the 1974 SSZ Map of the Calaveras Reservoir quadrangle is based on Dibblee (1972) (figure 2b). Dibblee shows the Clayton fault as offsetting Tertiary Monterey Shale and Briones sandstone against Cretaceous Oakland Conglomerate. The Clayton fault of Dibblee is a high-angle

right-lateral strike-slip fault (figure 2b). Deposits of older alluvium (Qoa) are not offset by the Clayton fault (figure 3b).

Four fault investigation reports are on file with CDMG. Two fault investigations (Richard Rowland, 1975; Purcell, Rhoades and Associates, 1978), located a bedrock fault with no evidence of offset soil, colluvium, or alluvium. JCP-Geologists (1977) located the Clayton fault and recommended a building setback, based on offset gravels in a cut slope. However, a trench excavated across the fault exposed a bedrock fault dipping 45° to the southwest. The fault did not extend into the overlying gravel material (late Pleistocene in age).

Geomorphic evidence for recent faulting cannot be found along the Clayton fault trace, based on air photo interpretation by this writer and mapping by Herd (in press) (figure 3b).

"Crothers Road Fault"

This inferred fault (figure 3b) was not included on the 1974 SSZ Map of the Calaveras Reservoir quadrangle and Dibblee (1973) does not show this fault (figure 2b). However, a fault investigation by R.L. Rose (1974) located a northeast dipping high-angle reverse fault that juxtaposed Cretaceous Berryessa Formation against Cretaceous Oakland Conglomerate (figures 2b, 3b). The overlying soil had a pronounced moisture contrast, and the consultant assumed this implied that the fault extended into the soil. This moisture barrier doesn't necessarily require faulting, since a difference in bedrock lithology, such as the rocks exposed during this investigation, would produce different soils. The downslope location of the Berryessa Shale, and the clay-rich soil derived from the shale, would tend to impede downslope migration of water and produce similar features observed during this fault investigation. Rose stated that the fault was probably contemporaneous with Plio-Pleistocene age folding of the Tertiary Briones Formation. A fault investigation by R.L. Rose (1975) 3000 feet southeast

of Rose (1974) did not find evidence of faulting along the projected trace of the "Crothers Road fault" (figure 2b).

Herd (in press) shows concealed traces of the "Crothers Road fault" just southwest and parallel to Crothers Road (figure 2b). The "Crothers Road fault" based on air photo interpretation by this writer, is expressed by back-facing scarps, sidehill bench, vague trough, and associated deflected drainages (both left and right-lateral) (figure 3b). The geomorphic features are closely associated with landslide features, but vague continuity can be observed to the southeast on the San Jose East quadrangle. A landslide conceals the "Crothers Road fault" trace to the northwest.

The southeast projection of the "Crothers Road fault" will be evaluated in FER-106. Based on preliminary air photo interpretation by this writer and mapping by Herd (in press), the "Crothers Road fault" may delineate the main trace of the Hayward fault in this region. The segment of the Hayward fault on the southern Calaveras Reservoir quadrangle mapped by Dibblee (1973) is not well-defined and is delineated primarily by stratigraphic relationships.

Evergreen Fault

The northern-most segment of the Evergreen fault of Dibblee (1972) was included on the 1974 SSZ Map of the Calaveras Reservoir quadrangle (figure 2b). Evidence for the Evergreen fault is located principally to the southeast on the San Jose East quadrangle (Dibblee, 1972b), and will be more extensively discussed in FER-106.

Four fault investigations have been conducted along the trace of the Evergreen fault in the Calaveras Reservoir quadrangle (R.L. Rose, 1976; F.A. Stejer, 1977; E.A. Danehy, 1979; Terratech, 1979) (figure 2b). No evidence for faulting was found, except for Terratech, 1979. (Refer to Quimby fault discussion for review of Terratech, 1979). Danehy (1979) suggests that the Evergreen fault may be located about 300 feet west of the fault

investigation site, based on the relatively shallow depth to bedrock interpreted from seismic refraction profiles.

Herd (in press) mapped a trace of the Evergreen fault that offsets older alluvium of late Pleistocene age west of Dibblee's trace (figure 2b). Herd shows a moderate to low angle east-dipping reverse fault that coincides with Danehy's postulated trace of the Evergreen fault. The trace of the Evergreen fault interpreted from air photos by this writer is delineated by a modified, but well-defined scarp that coincides with that of Herd (figure 2b, 3b).

Inferred Fault of Radbruch (1868)

The inferred fault of Radbruch (1968 & 1974) was based on reports of probable cracks caused by the 1868 earthquake (figure 2a). Hart (1979) removed this trace from the Niles SSZ Map because the ground cracks in the Niles quadrangle were ^{considered} to be associated with landsliding, not fault rupture. Herd (1977) does not show this fault trace on the Milpitas quadrangle, nor does Dibblee (1972) (figure 2a). Dibblee mapped the contact between Tertiary Briones Formation and Orinda Formation near the location of Radbruch's fault trace (1972). No specific geomorphic evidence for this fault trace can be found, based on air photos interpretation by this writer, except for a crude alignment of saddles, which are equally ^acomptable with differential erosion of contrasting lithologies. Drainages show no evidence of systematic offset.

Unnamed Fault of Dibblee (1972)

Dibblee mapped a northwest-trending fault about 4000 feet east of the main trace of the Hayward fault (figure 2a). Dibblee shows the Plio-Pleistocene Santa Clara Formation to be offset against Tertiary Briones Formation. Hart (1979) removed the projected trace of this fault in the Niles SSZ Map based on: 1) Holocene alluvial deposits are not offset; 2) no geologist has mapped the fault as active or potentially active; 3) no evidence of geomorphic features found on 1939 USGS air photos; 4) fault investigation did not reveal an active

fault. However, most of this information is pertinent only to the Niles quadrangle. Herd (1977) shows evidence of late Quaternary faulting along the southeastern segment of Dibblee's fault trace (figure 2a). Offset of drainages is not present and Holocene alluvial deposits are not offset. Discontinuous geomorphic evidence, principally scarps and saddles in Pleistocene Irvington gravels, can be observed on 1939 SCS air photos (figure 3b).

Mission Fault - Southeast Segment

The southeastern extent of the Mission fault is depicted by Dibblee (1973) as concealed and ~~quarried~~ ^g (figure 3b). Deposits of late-Pleistocene alluvium are not offset by this fault. Herd (in press) could not find evidence for late Quaternary offset along this fault trace. Hart (1979) removed the SSZ on the adjacent Niles quadrangle, based on the lack of evidence of Holocene offset.

6. Conclusions

The southeastern extension of the Hayward fault zone is characterized by an extremely complex zone of compressional features, especially southeast of the Milpitas quadrangle. Well-defined right-lateral strike-slip faulting occurs at the northern part of the Milpitas quadrangle, but to the south it rapidly develops into a complex zone of high-angle right-lateral strike-slip and moderate to low-angle reverse-oblique faulting. Lithologic relationships are very complex, and many formations (such as the Franciscan Formation and associated Cretaceous sedimentary rocks) are highly sheared or internally deformed from many episodes of deformation. Intense, massive landsliding, both shallow and large scale, occurs throughout this part of the Diablo Range. Slope failures along these west-facing slopes further complicate interpretation of geomorphic features, stratigraphic relationships, and features exposed during subsurface investigations.

Discontinuous, locally well-defined geomorphic features suggestive of Holocene faulting can be observed along traces of the Crosley, Evergreen, main trace Hayward, and "Crothers Road" faults, but through-going fault features generally cannot be observed.

The Hayward fault is well-defined in the northern part of the Milpitas quadrangle from the quadrangle boundary south to Mission Boulevard (figure 3a). Southeast of Mission Boulevard, evidence of faulting is discontinuous, but locally well-defined (Herd, 1977; this report, figure 3a).

Geomorphic evidence of systematic offset on the Calaveras Reservoir quadrangle is obscured by recent landslides and erosion, although local geomorphic features may be associated with faulting in the area from near the T.55./T.6S. boundary southeast for about 2 miles (figure 3b).

Herd (in press) does not show traces of the Hayward fault on the Calaveras Reservoir quadrangle. Active, massive landsliding is the dominant geologic process along most of the stretch of the Hayward fault in the Calaveras Reservoir quadrangle.

The Hayward fault is delineated primarily by stratigraphic relationships from the area near Berryessa Creek southeast to the south boundary of the Calaveras Reservoir quadrangle (Dibblee, 1973). No evidence of Holocene activity can be observed along the Hayward fault of Dibblee in this region, and the fault is not well-defined. The "Crothers Road fault", located about 1500 feet southwest of Dibblee's fault trace, may be the main active trace of the Hayward fault in this region.

Crosley Fault

Geomorphic evidence for the Crosley fault is inconclusive. Major portions of the fault trace are obscured by recent landsliding. Herd (in press) does not show traces of the Crosley fault on the Calaveras Reservoir or the Milpitas quadrangles. There is no geomorphic evidence for Holocene faulting in the Milpitas

quadrangle and the fault is only generally depicted along the base of the hill front.

Local evidence for recently active faulting (mainly tonal lineaments in recent landslide deposits) can be found between Berryessa Creek and Crosley Creek, but geomorphic evidence of systematic offset along the Crosley fault cannot be found.

Alquist-Priolo fault investigations reports on file with CDMG generally are inconclusive or contradictory with regard to the location and recency of activity of the Crosley fault. Evidence of offset Holocene deposits has been found in the area between Berryessa Creek and Cro^Pley Creek (Hull and Associates, 1977; Earth Systems Consultants 1978a&b; Kaldveer and Associates, 1978) (figure 2b). Burkland and Associates (1977a; 1977b) exposed faults offsetting soil along the mapped trace of the Crosley fault in the Milpitas quadrangle (figure 2a). However, ^{just south} ~~first~~ of these sites Burkland and Associates (1976) found no evidence for faulting along the mapped trace of the fault (figure 2a). Elsewhere along the Crosley fault trace evidence from fault investigations is contradictory, or alternative explanations for exposed features are possible.

The Crosley fault of Dibblee (1972 & 1973) depicted on the SSZ Maps of the Milpitas and Calaveras Reservoir quadrangles is a generalized depiction of a very complex zone of discontinuous faults. The discontinuous nature of mappable fault traces within the zone is further complicated by landslide features that obliterate or mimic fault features anticipated in a reverse-oblique style of faulting.

Berryessa Fault

Evidence for recent activity along the Berryessa fault has not been found. Dibblee (1973) depicts the fault as a right-lateral strike-slip fault that offsets Plio-Pleistocene Santa Clara Formation, but Holocene alluvium ^{shown to be} is not offset. Shears were found in "colluvial" deposits by Cotton and Associates (1979) in a road cut exposure, but trenching across the projected trace of this feature revealed

three feet of undisturbed soil. The "colluvium" may be Plio-Pleistocene Santa Clara Formation.

Other fault investigations did not find evidence for Holocene activity along the Berryessa fault. Herd (in press) could not find evidence for late Quaternary traces of the Berryessa fault. The Berryessa fault is not a well-defined feature and evidence for Holocene activity has not been found.

Quimby Fault

Only the very northern part of the Quimby fault of Dibblee (1973) is shown on the Calaveras Reservoir quadrangle. The Quimby fault does not offset late Pleistocene alluvial deposits and geomorphic evidence for recent faulting is not present (figure 3b). Herd (in press) does not show late Quaternary traces of the Quimby fault. Fault investigations involving trench excavations have not demonstrated recent offset (see FER-106).

Clayton Fault

The Clayton fault of Dibblee (1973) is depicted as a high-angle right-lateral strike-slip fault. Late-Pleistocene alluvial deposits are not offset by the Clayton fault (Dibblee, 1973). Specific site investigations have generally located bedrock faulting that doesn't offset younger alluvial or colluvial deposits. JCP-Geologists (1977) found shears in gravel deposits in a cut slope, but trenching across the projected trace of this feature revealed bedrock faulting that did not extend into the overlying gravel material (late Pleistocene). Herd (in press) does not show late-Quaternary traces of the Clayton fault. Geomorphic evidence of recent faulting is not present along the trace of the Clayton fault and the criteria of sufficiently active and well-defined are not met.

"Crothers Road Fault"

The "Crothers Road fault" offsets sedimentary rocks of Cretaceous age and is inferred to offset overlying soil deposits (Rose, R.L., 1974). Evidence for the offset of soil is very weak and alternative explanations excluding faulting are just as compatible. Rose (1974) stated that this fault was probably contemporaneous with folding of Tertiary Briones Formation, and was probably about 5 my old. Herd (in press) shows concealed traces of the "Crothers Road fault" and geomorphic features permissive of Holocene faulting locally could be found by this writer (figure 3b). Systematic offset is not apparent along this fault trace, but farther southeast on the San Jose East quadrangle, systematic right-lateral deflection of drainages associated with discontinuous scarps and tonal lineaments in alluvium align with the general trend of the "Crothers Road fault" (refer to FER-106).

Evergreen Fault

The northern-most segment of the Evergreen fault of Dibblee (1973) is depicted as concealed on the Calaveras Reservoir quadrangle. A-P fault investigations along the mapped trace of the Evergreen fault did not expose evidence of faulting. Herd (in press) shows a sinuous trace of the Evergreen fault that offsets late-Pleistocene alluvial deposits. The Evergreen fault trace, based on air photo interpretation by this writer, coincides with the trace mapped by Herd (figure 2b, 3b). The fault trace of Herd (in press) is well-defined and is characterized by a generally west-facing scarp in older alluvium (Helley and Brabb, 1972).

Inferred Fault of Radbruch (1868)

Dibblee (1972) and Herd (1977) have not mapped this inferred fault that was mapped by Radbruch (1968, 1974) based on reports of ground cracks associated

quadrangle and the SSZ was subsequently deleted. No evidence for faulting can be observed along Radbruch's inferred trace in the Calaveras Reservoir quadrangle.

Unnamed Fault of Dibblee (1972)

This fault trace east of the Hayward fault zone offsets Plio-Pleistocene Santa Clara Formation (Dibblee, 1972). Hart (1979) did not find evidence for the projected trace of this fault on the Niles quadrangle and recommended removal of the projected SSZ. Herd (1977) shows scarps in Pleistocene Irvington Gravels associated with saddles indicating that the geomorphic evidence is principally erosional. Herd's fault traces partly coincide with the southeastern part of Dibblee's fault trace. Holocene alluvium is not offset and systematic offset of ridges and drainages is not present.

Mission-Fault - Southeast Segment

This fault does not offset deposits of late Pleistocene alluvium, based on Dibblee (1973). Herd (in press) does not show late-Quaternary faulting along Dibblee's concealed and queried trace. Hart (1979) removed the Mission fault SSZ because the fault did not meet the criteria of sufficiently active and well-defined. The fault trace on the Calaveras Reservoir quadrangle is not sufficiently active or well-defined.

7. Recommendations

Recommendations for zoning faults for special studies are based on the criteria of sufficiently active and well-defined (Hart, 1980).

Hayward Fault

Zone for Special Studies those traces of the Hayward fault mapped on the Milpitas quadrangle by Dibblee (1972), Herd (1977), and Bryant (figure 3a, this report) (figure 4a). Delete the trace of Crittenden (1951) Burkland and Associates (1974), and certain traces of Dibblee (1972) as shown on figure 4a.

Modify traces of the Hayward fault on parts of the Calaveras Reservoir quadrangle, based on figure 3b of this report. Dibblee's main trace of the Hayward fault is not well-defined in some parts of the Calaveras Reservoir quadrangle, but adequate data does not exist along parts of the fault traces to justify modification of the fault location.

At the south end of the Calaveras Reservoir quadrangle, modify the location of the main trace of the Hayward fault to coincide with the "Crothers Road fault", based on Herd (in press) and figure 3b of this report.

Crosley Fault

Retain the Crosley fault of Dibblee (1972) on the Milpitas quadrangle (figure 4a).

Modify traces of the Crosley fault, based on Herd (in press) and figure 3b of this report (figure 4b). Traces of the Crosley fault generally are not well-defined, or are obscured by Holocene and historic landslides. However several fault investigations have exposed evidence of Holocene movement of the Crosley fault. It should be realized that evaluation of a reverse-oblique fault such as the Crosley fault is extremely difficult and that traces of the fault recommended for zoning may be only a general approximation of a very complex zone of compressional strain.

Berryessa Fault

Delete the SSZ and traces of the Berryessa fault on the Calaveras Reservoir quadrangle (figure 4b). The Berryessa fault is not sufficiently active or well-defined.

Quimby Fault

Delete the trace of the Quimby fault shown at the south end of the Calaveras

Reservoir quadrangle (figure 4b). The Quimby fault is not sufficiently active or well-defined and may not exist as depicted by Dibblee (1973).

Clayton Fault

Delete traces of the Clayton fault on the Calaveras Reservoir quadrangle.

"Crothers Road Fault"

Refer to recommendations for the Hayward fault.

Evergreen Fault

Modify the trace of the Evergreen fault, based on Herd (in press) and figure 3b of this report (figure 4b). The decision to modify the zone of the Evergreen fault is based on a well-defined, but modified, west-facing scarp in alluvium of questionable Holocene or very late Pleistocene age.

Inferred Fault Trace of Radbruch (1868)

Delete the trace of Radbruch's (1968 & 1974) inferred fault on the Milpitas quadrangle, based on Hart (1979) and the lack of evidence of sufficiently active and well-defined (figure 4a).

Unnamed Fault of Dibblee (1972)

Delete the fault zone of Dibblee (1972), based on Hart (1979) (figure 4a). Herd (1977) mapped late Quaternary traces that closely coincide with Dibblee (1972), but Herd's trace does not meet the criteria of sufficiently active.

Mission Fault - Southeast Segment

Delete the trace of Dibblee (1973) shown on the Calaveras Reservoir quadrangle. This fault trace is not sufficiently active or well-defined, and the northwest projection of this fault was not found to be sufficiently active or well-defined by Hart (1979).

8. Report prepared by William A. Bryant, December 19, 1980.

William A. Bryant

*I concur with
the recommendations.
EAB
2/6/81*

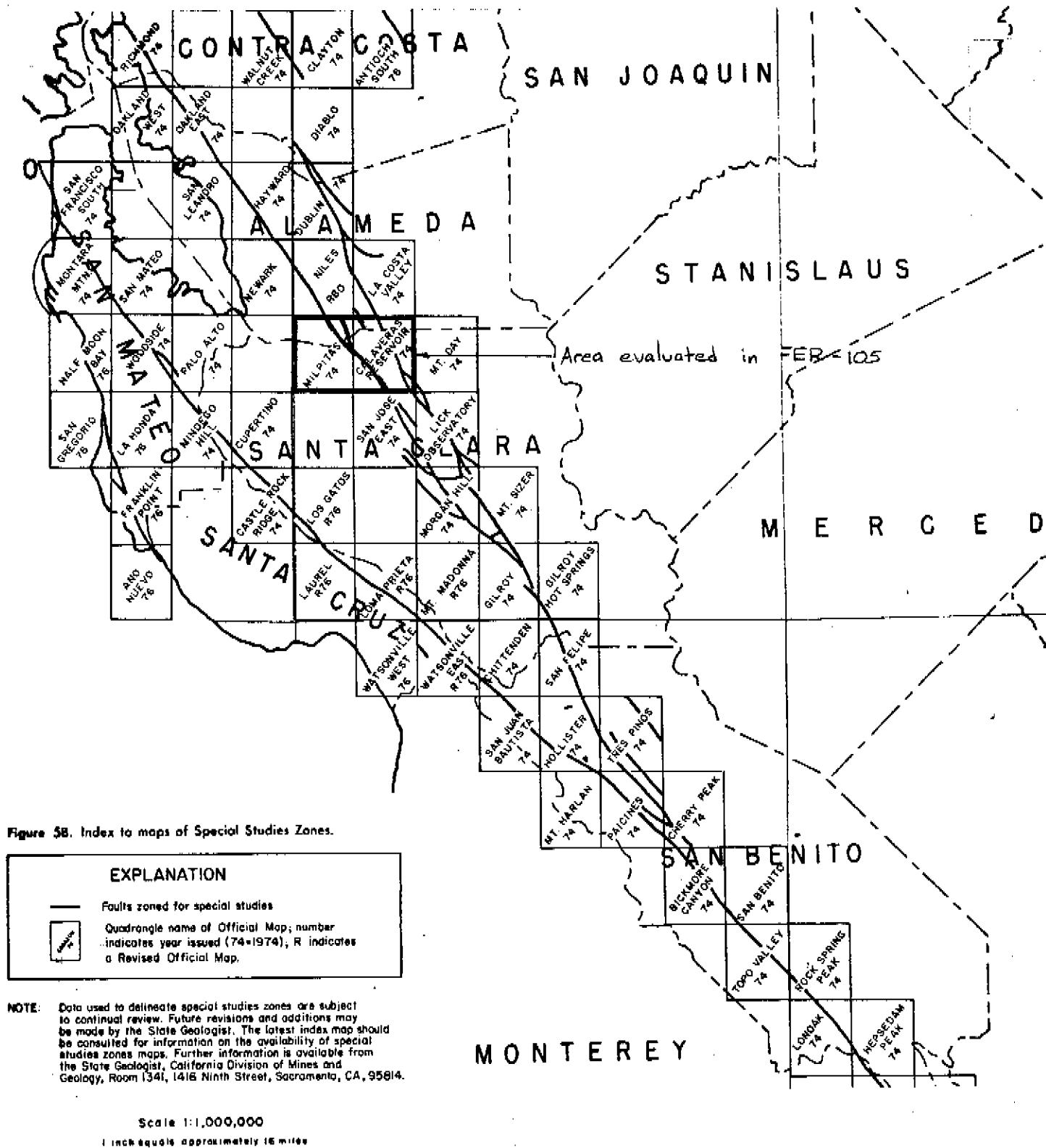


Figure 1 (to FER-105). Location of Hayward fault zone (shown in green) to be evaluated in this FER. Map from Hart (1980, p. 13).